

SHORT COMMUNICATION
ΒΡΑΧΕΙΑ ΔΗΜΟΣΙΕΥΣΗ

ARCHIVES OF HELLENIC MEDICINE 2024, 41(2):275–278
ΑΡΧΕΙΑ ΕΛΛΗΝΙΚΗΣ ΙΑΤΡΙΚΗΣ 2024, 41(2):275–278

**Application of Heisenberg's
uncertainty principle in children
with appendicitis**
False-negative × false-positive errors

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Η εφαρμογή της αρχής της απροσδιοριστίας
του Heisenberg σε παιδιά με σκωληκοειδίτιδα:
Ψευδώς αρνητικά × ψευδώς θετικά
διαγνωστικά σφάλματα

Περίληψη στο τέλος του άρθρου

Key words: Appendicitis, Children, Diagnostic errors, Uncertainty principle

*For it is a great shame for this beautiful
anguish to turn into a boring habit*

D. Liantinis

The Heisenberg Uncertainty Principle is a fundamental theory in quantum mechanics that defines why a scientist cannot determine complementary or canonically conjugated variables simultaneously without a characteristic inaccuracy. Werner Heisenberg imagined an experimenter trying measure the position and momentum of an electron by shooting a photon at it. When photon energy was of low frequency, electron's momentum was determined but its position was unknown. When photon energy was of high frequency, electron's position was detected but its momentum was not specified. When photon energy was of average frequency, "such that", the position and momentum of the electron could be simultaneously and accurately determined, but only within the smallest possible

errors. The electron's position was roughly determinable and its momentum roughly retrievable.¹ This "roughly" is the Uncertainty Principle that corresponds to the smallest possible error in the determination of the position Δp and the smallest possible error in the determination of the momentum Δq of the electron, and their product could never be smaller than Planck's constant – $\Delta p \Delta q \geq h$.¹ If we leave the logic of "either...or" behind and use the logic of "such that" instead, our contradictory thought will then become complementary.¹ So, Aristotle's classical logic of reality is superseded.

These uncertainty errors, although dominant in the microcosm, appear on a very small scale in the macrocosm of our daily life, and are not due to man's inability to observe or measure certain phenomena, but due to the actual property of the physical world. There are millions of examples that tell us about uncertainty. Although these errors are negligible on a human scale, they cannot be ignored.² Uncertainty "neither speaks plainly nor conceals, but indicates by signs", according to its first conception by Heraclitus.¹

By analogy, a similar type of uncertainty principle appears to affect the medical relationship between the minority of patient's well-being and the diagnostic knowledge about the underlying disease.³ The object of the clinical consultation is to give a diagnostic designation followed by a treatment regimen that will solve the problem,² with the least of early or late harmful consequences. This is a base process, complicated sometimes by understood or understood factors and variables, which add an uncertainty to it.² Diagnostic uncertainty is an inherent dynamic state of medical practice, defined as a subjective perception of inability to provide accurate patient health problem management,⁴ as well as in proper time. There are concerns over the diagnostic uncertainty associated with medical management and how this uncertainty may result

in a drift toward the over-diagnosis and over-treatment of presumed appendicitis,⁵ or the under-diagnosis and delayed treatment under special circumstances. Perforated appendicitis due to physician's missed diagnosis as under-diagnosis errors, and negative appendectomies as over-diagnosis errors, are the Δp and Δq .

Acute appendicitis is one of the most common causes of abdominal pain and is the most frequent condition requiring emergent intra-abdominal surgery in children.⁶ It still remains an ongoing clinical and diagnostic challenge, due to potential atypical and or clouding presentation with a wide range of differential diagnoses, with a higher risk for delayed diagnosis/perforation and associated complications, increasing morbidity – prolonged hospitalization and even mortality in young children.⁷ The rate of pediatric perforated appendicitis often refers at approximately 30%, with a range from 20% to 74%.^{8,9} It may be much higher in younger children, ranging between 69–93% in children aged two to five years and up to 100% for one-year-old children.^{8,9} Perforation occurs rarely during the first 12 hours of symptoms, but is more likely with time thereafter (36–48 hours), and becoming very common after 72 hours.^{9,10} Perforation rate is doubled when in-hospital delay prior to surgery exceeded 24 hours.¹¹ Negative appendectomy rates up to 25% were justified, in order to avoid the morbidity of missed perforated appendicitis.¹² The reported negative appendectomy rate was 6.7% in a population of 250,783 children.¹³ Ultrasound (US) and computed tomography (CT) imaging have an ever-increasing role in the prompt and accurate diagnosis of acute appendicitis in the pediatric population, improving the rupture rates,⁶ and also reducing the negative appendectomy rates over the last decade.¹⁰ The incidence of negative appendectomies due to diagnostic uncertainty has significantly decreased, but still remains remarkable.¹¹ At the same time, many cases of acute appendicitis are still missing.¹¹ At least 4.8% of children who underwent appendectomy had missed opportunities to diagnose their condition at earlier medical visits.¹⁴ In one study, 1.3% of children with potentially missed appendicitis had received a CT scan at the index visit.¹⁵ A staged US and unenhanced magnetic resonance imaging (MRI) algorithm for the appendicitis diagnosis seems to be feasible, effective, and preferable in children.¹⁶ The negative appendectomy rate in a cohort study was 0.2% (four of 1,982 cases).¹⁶ According to pediatric surgeons, this was lower than the institutional reported overall negative appendectomy rate, which was less than 2%.¹⁶ The final diagnosis will still be uncertain in a minority of children, because there will be no pathologic imag-

ing diagnosis to provide a “check and balance” against trends in overreading by well-meaning radiologists, or to acting on such reads by equally well-meaning pediatric surgeons.⁵ A drift toward the overtreatment of children with increasingly early diagnosed appendicitis albeit with equivocal or borderline imaging results is also possible, as the threshold for initiating operative exploration is likely to be lower, especially when considering the consequences of a “wrong” treatment decision.⁵ Furthermore, the vermiform appendix is no longer considered as a redundant remnant of evolution without essential function. An early appendectomy is expected to significantly reduce the intestinal immunoreactivity and alter the gut microbiome,^{17,18} and may be associated with an increased risk of several diseases.^{19,20} Since the child is a growing organism with a long life-expectancy, any intervention such as appendectomy could cause a long-term impact.

Thus, if the adverse events (perforation, abscess formation, sepsis, prolonged ileus, delayed bowel obstruction, etc.) correlate with physician false negative decisions, then unnecessary surgeries correlate with physician false positive decisions in abdominal pain evaluation.¹¹ In short, the uncertainty principle describes a trade-off between negative appendectomy and complicated appendicitis. False-negative errors (Δp) \times false-positive errors (Δq) > 0 . If the value of one of the errors increases, then the value of the other error decreases. If we try to eliminate negative appendectomies, the complicated appendicitis incidence increases. If we try to catch up complicated appendicitis, the negative appendectomies rate increases. Despite imaging technology improvements, neither negative appendectomies nor complicated appendicitis rates can be made zero.

Erwin Schrödinger's cat is a remarkable thought experiment as evidence of the Uncertainty Principle in the macrocosm. The experiment was done in this way: a cat, a flask of poison, and a radioactive source are placed in an insulated opaque steel chamber. If even one single atom of the radioactive substance decays during the experiment, a Geiger counter detects radioactivity and the flask is shattered, releasing the poison, which kills the cat. Is the cat alive or dead after a while? You could answer that the cat is dead, but maybe the flask is not yet shattered. You could answer that it is alive, but what if the flask has been shattered? Neither answer is possible without looking inside the chamber. Only one answer is possible. “...Nor answer A (the cat is alive), nor answer B (the cat is dead), but answer C: “The cat remains in a uniquely possible state inside the chamber, is dead-alive, it exists in a hybrid state...”¹ But when one looks into the chamber, quantum superposition ends and reality resolves into a living cat or a dead cat.

However, there comes a time when a therapeutic decision needs to be made and further investigations are unlikely to yield more certainty.²¹ Close observation with serial abdominal clinical examinations is indicated for a child with acute abdominal pain and not a definite diagnosis, due to the absence of convincing clinical findings or presentation of confused imaging results or lack of advanced imaging modalities. This uncertain medical situation cannot be time consuming. A p eye perceives the image of a child with appendicitis. It constitutes one-half of the winning probability, or direct intervention with a minimum risk of negative appendectomy. The other q eye perceives the image of a child without appendicitis. It is the other half of the winning probability, or avoiding an unnecessary operation with a minimum risk of perforation and delay intervention. Looking with both eyes is equivalent to not looking at all, and yet you are obliged to give an answer about what is happening “inside the chamber”, the cat is dead-alive.¹ Simultaneous prompt and accurate diagnosis cannot be precise, and comes with a relative uncertainty. Surgeons who can navigate the often-narrow channel between under-confidence and overconfidence are best equipped to conquer uncertainty and serve children well, either by judicious immediate intervention or with masterly inactivity.²¹ Uncertainty is exactly this moment of lightning,¹ is the narrow channel's navigation just before the surgical or not decision – until its confirmation. After the decision, the quantum superposition ends and reality resolves into a negative appendectomy or an intervention of perforated appendicitis.

We physicians do not enjoy uncertainty, and to have it formalized is uncomfortable.² So, we instinctively treat the possible major problem.² It is however important to see this as a convenience, that may not always suit the patient.² A systematic pediatric institutional approach should be associated with improved perforation rates and appendicitis outcomes while favoring reduced rates of negative appendectomy, due to the potential harmful long-term effects of appendectomy in children. The incidence of complicated appendicitis and negative appendectomies due to diagnostic uncertainty has been significantly decreased but cannot be ignored, and especially eliminated. Gain the uncertainty by achieving a balance between the unnecessary removal of too few normal appendices and the late removal of too few inflamed appendices. According to the Heisenberg Uncertainty Principle, there is a fundamental limit to the accuracy by which the “conjugated variables” of negative appendectomy and complicated appendicitis cannot be further reduced simultaneously.

ΠΕΡΙΛΗΨΗ

Η εφαρμογή της αρχής της απροσδιοριστίας του Heisenberg σε παιδιά με σκωληκοειδίτιδα: Ψευδώς αρνητικά × ψευδώς θετικά διαγνωστικά σφάλματα

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Αρχεία Ελληνικής Ιατρικής 2024, 41(2):275–278

Η αρχή της απροσδιοριστίας του Heisenberg ορίζει την αβεβαιότητα ως πραγματική ιδιότητα της φύσης, που πρωταγωνιστεί στον μικρόκοσμο. Η ισχύς της περιορίζεται σε ορισμένες καταστάσεις φαινομένων του μακρόκοσμου, αντιληπτές από εμάς σε μικρή κλίμακα. Παρουσιάζουμε τη διαγνωστική αβεβαιότητα στα παιδιά με σκωληκοειδίτιδα. Σύμφωνα με την αρχή του Heisenberg, υπάρχει ένα θεμελιώδες όριο πέρα από το οποίο οι «συζευγμένες μεταβλητές» της αρνητικής σκωληκοειδεκτομής και της επιπλεγμένης σκωληκοειδίτιδας στα παιδιά δεν μπορούν να μειώνονται ταυτόχρονα.

Λέξεις ευρητηρίου: Αρχή απροσδιοριστίας, Διαγνωστικά σφάλματα, Διαγνωστική αβεβαιότητα, Παιδιά, Σκωληκοειδίτιδα

References

- LIANTINIS D. $\Delta p \Delta q \geq h$. In: Georgopoulou-Liantini N (ed) and Tsapras Y (Translation) *Gemma*. CreateSpace Independent Publishing Platform, Scotts Valley, California, 2013:108–120
- EASTWOOD MA. Heisenberg's uncertainty principle. *QJM* 2017, 110:335–336
- SONNENBERG A. A medical uncertainty principle. *Am J Gastroenterol* 2001, 96:3247–3250
- BHISE V, RAJAN SS, SITTIG DF, MORGAN RO, CHAUDHARY P, SINGH H. Defining and measuring diagnostic uncertainty in medicine: A systematic review. *J Gen Intern Med* 2018, 33:103–115
- BACHUR RG, RANGEL SJ. The threat of diagnostic uncertainty in the medical management of uncomplicated appendicitis. *JAMA Pediatr* 2017, 171:505–506
- ROUPAKIAS S, APOSTOLOU MI, ANASTASIOU A. Acute appendicitis in a diabetic child with *Salmonella* infection. *Prague Med Rep* 2021, 122:34–38
- SINGH M, KADIAN YS, RATTAN KN, JANGRA B. Complicated appendicitis: Analysis of risk factors in children. *Afr J Paediatr Surg* 2014, 11:109–113
- ZAVRAS N, VAOS G. Management of complicated acute appendicitis in children: Still an existing controversy. *World J Gastrointest Surg* 2020, 12:129–137
- HOWELL EC, DUBINA ED, LEE SL. Perforation risk in pediatric appendicitis: Assessment and management. *Pediatric Health Med Ther* 2018, 9:135–145

10. BRANDT ML, LOPEZ ME. *Acute appendicitis in children: Clinical manifestations and diagnosis*. UpToDate, 2023. Available at: <https://www.uptodate.com/contents/acute-appendicitis-in-children-clinical-manifestations-and-diagnosis>
11. GRAFF L, RUSSELL J, SEASHORE J, TATE J, ELWELL A, PRETE M ET AL. False-negative and false-positive errors in abdominal pain evaluation: Failure to diagnose acute appendicitis and unnecessary surgery. *Acad Emerg Med* 2000, 7:1244–1255
12. MALONEY C, EDELMAN MC, BOLOGNESE AC, LIPSKAR AM, RICH BS. The impact of pathological criteria on pediatric negative appendectomy rate. *J Pediatr Surg* 2019, 54:1794–1799
13. OYETUNJITA, ONG'UTI SK, BOLORUNDURO OB, CORNWELL EE 3rd, NWOMEH BC. Pediatric negative appendectomy rate: Trend, predictors, and differentials. *J Surg Res* 2012, 173:16–20
14. NAIDITCH JA, LAUTZ TB, DALEY S, PIERCE MC, REYNOLDS M. The implications of missed opportunities to diagnose appendicitis in children. *Acad Emerg Med* 2013, 20:592–596
15. MAHAJAN P, BASU T, PAI CW, SINGH H, PETERSEN N, BELLOLIO MF ET AL. Factors associated with potentially missed diagnosis of appendicitis in the emergency department. *JAMA Netw Open* 2020, 3:e200612
16. DIBBLE EH, SWENSON DW, CARTAGENA C, BAIRD GL, HERLICZEK TW. Effectiveness of a staged US and unenhanced MR imaging algorithm in the diagnosis of pediatric appendicitis. *Radiology* 2018, 286:1022–1029
17. SÁNCHEZ-ALCOHOLADO L, FERNÁNDEZ-GARCÍA JC, GUTIÉRREZ-RE-PISO C, BERNAL-LÓPEZ MR, OCAÑA-WILHELMI L, GARCÍA-FUENTES E ET AL. Incidental prophylactic appendectomy is associated with a profound microbial dysbiosis in the long-term. *Microorganisms* 2020, 8:609
18. CAI S, FAN Y, ZHANG B, LIN J, YANG X, LIU Y ET AL. Appendectomy is associated with alteration of human gut bacterial and fungal communities. *Front Microbiol* 2021, 12:724980
19. BABAKHANOV AT, DZHUMABEKOV AT, ZHAO AV, KUANDYKOV YK, TANABAYEVA SB, FAKHRADIYEV IR ET AL. Impact of appendectomy on gut microbiota. *Surg Infect (Larchmt)* 2021, 22:651–661
20. DING RX, GOH WR, WU RN, YUE XQ, LUO X, KHINE WWT ET AL. Revisit gut microbiota and its impact on human health and disease. *J Food Drug Anal* 2019, 27:623–631
21. ARONSON JK. When I use a word Too much healthcare-uncertainty, underconfidence, and masterly inactivity. *Br Med J* 2022, 378:o2305

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